FINAL

GEOTECHNICAL & GEOENVIRONMENTAL DESK STUDY

Kintore Flood Study

Project no. 4021839

Prepared for:

Aberdeenshire Council

21st March 2025

Enhancing lives, communities and the environment

Details of document preparation and issue:

Version no.	Prepared	Checked	Reviewed	Approved	Issue date	Issue status
P01	S Rebours-Smith	B Tucker	L. Westoby	A Lamb	22/11/24	DRAFT
P01	S Rebours-Smith	B Tucker	L. Westoby	A Lamb	21/03/25	FINAL

Project no. 4021839 Client's reference no. W763064

File name: 4021839-BUK-ZZ-00-RP-GE-00002

Table of contents

1. INTRODUCTION

1.1 Instruction

Binnies UK Limited (BUKL) was instructed by Aberdeenshire Council (Aberdeenshire), the Client, to provide a high level Geotechnical and Geoenvironmental Desk Study to aid the Kintore Flood Study.

1.2 Proposed works

Designs for the proposed flood protection works have not been finalised at the time of writing. Therefore, this report should be reviewed and may need to be amended accordingly once detailed designs are known.

1.3 Scope

The purpose of this desk study is to collate available geological and environmental data for the study area (and its environment) and provide a high level geotechnical and geo-environmental appraisal, with a site-specific conceptual site model. This enables a preliminary assessment of ground risks to be undertaken and, if necessary, provides information for the design of a ground investigation (GI). The scope of this report is based on the following objectives:

- Carry out a review of the historic developments of the study area and surrounding area;
- Assess the study area's anticipated ground conditions including geology, hydrology, and hydrogeology;
- Assess the risk of ground gas generation and accumulation including radon;
- Assess the potential risks from past and present mining and quarrying activities;
- Review relevant information held by appropriate statutory authorities;
- Review of any previous site investigation reports available;
- Identify potential geotechnical risks in relation to the proposed works;
- Develop a preliminary conceptual site model (pCSM);
- Compile a preliminary risk register considering the geotechnical and geoenvironmental constraints and hazards in relation to the proposed works;
- Identify the need for any additional investigations/studies and include recommendations for ground investigation, if required.

This desk study has been carried out following relevant guidance documents published by the British Standards Institution , the Environmental Agency (EA) and the Association of Geotechnical & Geoenvironmental Specialists (AGS), as referenced throughout the report.

The "vicinity" of the study area for the purposes of this report is defined as locations situated within an approximate 250m radius of the study area, although certain features further than 250m may also have been considered.

At the time of writing, a site walkover has not been conducted as part of these works by a Binnies Geotechnical or Geoenvironmental Engineer.

1.4 Limitations and uncertainties

This report has been written to provide a high level overview of the geotechnical and geoenvironmental conditions at the study area and only freely available published information has been used to inform this report. Additional data sources are available at cost and further detailed study should be undertaken once design proposals have been finalised.

1.5 Sources of information

The content of this report has been developed using the existing geotechnical and ground related information made available. The following publicly available sources of information have been reviewed and all pertinent information has been summarised in this report.

- Topographical Maps ;
- British Geological Survey (BGS) Geological Maps, borehole records, and Memoirs;
- Aerial and Street View Photography;
- Records of Mines and Mineral Deposits ;
- UK Health Security Agency's Map of Radon ;
- Scotland's Environment Map
  (reviewed for Environmental, visual, cultural, agricultural and habitats designations)
- Unexploded Ordnance (UXO);
- Hydrogeology – Published BGS map;
- Scottish Environmental Protection Agency (SEPA) register of Special Sites;
- Scottish Flood Hazard and Risk Information ;
- Drinking water protected areas – Scotland river basin district: maps ;
- Aberdeenshire Council public register of contaminated land;
- Scottish Pollution Release Inventory;
- SEPA's waste site information.

2. SITE DETAILS

The "study area" is centred on the River Don and it's four tributaries in the town of Kintore. Kintore is located in Aberdeenshire and is within the Aberdeenshire Council local authority catchment. The study area is centred on national grid reference NJ 79101 15620 (What3Words - briefer.rubble.suave) and a representative postcode is taken as the one for the post office, AB51 0YL.

The town of Kintore is a mixture of residential and commercial developments in need of flood protection. The surrounding area is primarily agricultural in nature. A study area location plan including the extent of the study area is provided in Figure 1.

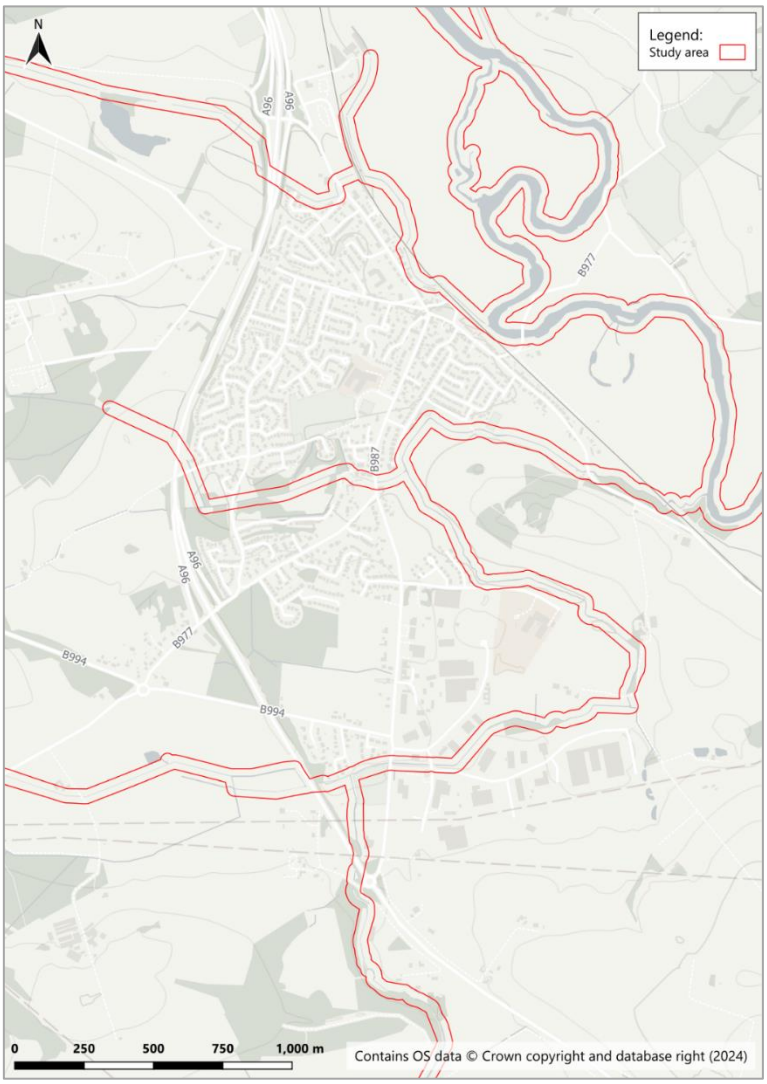

Figure 1: The study area

3. HISTORICAL AND ENVIRONMENTAL SETTING

3.1 Topography

Ground levels as indicated on historic Ordnance Survey (OS) plans range approximately between 53m OD to the north and 61m OD to the south of the study area . Much of the study area is located between Scroggie Hill, Gauch Hill and Tuach Hill.

3.2 Historical developments

The historical developments of the study area and surrounding area have been determined by reviewing historical plans, aerial photography and Google Street View photography. Available mapping dates from 1865 to the present day. However, it is noted that the historical data available does have gaps and may not give a full chronology of the development of the study area and surrounding areas. In general, only surrounding historical land uses within 250m of the study area and of environmental significance are reported.

A summary of the pertinent information is presented in Table 3-1, below. *Italicised text* represents potential receptors of note. Figure 2 shows potential sources of contamination; the figure references are included in parentheses in Table 3-1 where relevant.

Table 3-1: Summary of historical developments from available mapping

Revised Year	Series & Scale	On site developments	Vicinity of site
1865-1866	Ordnance Survey Aberdeenshire Sheet LXV six-inch to the mile	Town of Kintore shown, with Tavelty shown as "Upper Tilty" in the north, and Broomhill Plantation and Sheriff Burn in the south. Potentially contaminative land uses include: • Railway running north to south-east (e). • Unnamed pond north of Broomhill (k).	The vicinity is generally shown as agricultural. Numerous *Tumuli* (barrow burials), and hills observed to the south-west of the town. Notable land uses include: • Goods station (h) and Railway Station (i) (approximately 50m to the west). • Smithy adjacent to Railway Station (f) (approximately 30m m to the west). • Mill pond at Mid Mill (j), 100m north of the study area. • Cemetery (ll). • Gravel pit at Deers Den (approximately 300m east of study area) (z). • Quarry at Little Boghead (aa), 160m to the east. • Pond at Coolgardie (cc), 160m to the east. • Two ponds at Ferrybrae (dd), 250m to the east of the study area. • Four quarries or gravel pits at Tuach Hill (a,b,c,d) (closest is northern most one (a), 60m to the south). • *Remains of Aberdeen canal (gg),* immediately to the south. • *Embankment (fort)* at Coolgardie (bb), 190m m to the west).

Revised Year	Series & Scale	On site developments	Vicinity of site
1865	Ordnance Survey sheet Aberdeenshire LV.1 (Kintore) 25inch to the mile	No significant changes from previous map edition.	No significant changes from previous map edition.
1867	Ordnance Survey sheet Aberdeenshire LXV.5 25inch to the mile	No significant changes from previous map edition.	• Mill Dam at Tofthills (l), 75m to the west. • Quarry at site of Tumulus (ee), 110m to the south.
1899	Ordnance Survey Aberdeenshire Sheet LXV.1 25inch to the mile	No significant changes from previous map edition.	• Smithy no longer shown at Railway Station (f), Smithy shown approximately 200m south of original location (o), approximately 15m to the west of the study area. • Sand pit at Lands of the Holy Cross (m), 280m to the south of the study area. • Sewage tank (n), 10m to the south. • Pond at Torry burn farm (75m to the south of the study area) (ff).
1900	Ordnance Survey Aberdeenshire Sheet LXV.5 25inch to the mile	No significant changes from previous map edition.	No significant changes from previous map edition.
1901	Ordnance Survey Aberdeenshire Sheet LXV.NW six-inch	Town has expanded.	• Southernmost quarry at Tuach hill no longer shown (d).
1901	Ordnance Survey Aberdeenshire Sheet LXIV.NE six-inch	No significant changes from previous map edition.	• Quarries at Siller Hill (x, 480m south) and Womblehill (y, 490m south).
1925	Ordnance Survey Aberdeenshire Sheet LXV.1 25inch to the mile	• Power house (Aberdeen Electricity Supply Co.) shown at Torry Burn (q,r). • Electricity reservoir shown along Sheriff Burn (s). • *Kintore School.*	• Two northernmost quarries at Tuach Hill (a,b) now shown as tip or embankments.
1925	Ordnance Survey Aberdeenshire Sheet LXV.5 25inch to the mile	No significant changes from previous map edition.	No significant changes from previous map edition.
1925	Ordnance Survey Aberdeenshire Sheet LXV.NW	No significant changes from previous map edition.	• Sawmill shown in north of study area at Tavelty (w), 25m to the east of the study area.

Revised Year	Series & Scale	On site developments	Vicinity of site
	six-inch		• Pond at Tory burn and quarry at Deers Den no longer shown.
1938 (published circa 1949)	Ordnance Survey Aberdeenshire Sheet LXV.NW six-inch	No significant changes from previous map edition.	• Quarry at Coolgardie no longer shown. • Goods shed no longer labelled.
1959	Ordnance Survey sheet NJ71NE-A Ordnance Survey sheet NJ71SE-A (both 1:10,560)	• Electricity reservoir (s) no longer shown.	• Quarry at site of Tumulus (ee) no longer shown. • Quarries at Siller Hill and Womblehill now shown as spoil heaps or refuse tips. • Depot with tanks shown centre of town (now Dinnie Place) (p), 40m south of the study area. • Kintore Cemetery (kk) 350m to north of Loch Burn.
1965	Ordnance Survey sheet NJ7816-NJ7916-AA 1:2500	No significant changes from previous map edition.	• Station garage just north of train station (u), 30m to the south.
1966	Ordnance Survey sheet NJ7814-NJ7914-AA 1:2500	No significant changes from previous map edition.	No significant changes from previous map edition.
1966	Ordnance Survey sheet NJ7815-NJ7915-AA 1:2500	• Electrical substation shown at site of power house (q,r).	• Midmill filling station (t), 270m to the south-west.
1968	Ordnance Survey sheet NJ71NE-A 1:10,560	Town has expanded further.	• Works in centre of town (Upper Daugh) (w), 220m to the south-west. • Sand pit at Lands of the Holy Cross and sawmill at Tavelty no longer shown.
1968	Ordnance Survey sheet NJ71SE-A 1:10,560	No significant changes from previous map edition.	No significant changes from previous map edition.
1985	Aerial Photography from Google Maps	Very blurry imaging. No discernible information apparent.	Very blurry imaging. No discernible information apparent.
2003	Aerial Photography from Google Maps	Additional expansion of town	• Midmill Business Park (immediately east of study area) under construction. • Dinnie Place shown as residential (date of redevelopment from depot (p) unknown). • Sewage tank (n) now shown as fields, date of removal not known.
2007	Aerial Photography from Google Maps	No significant changes noted from previous imaging.	No significant changes noted from previous imaging.

Revised Year	Series & Scale	On site developments	Vicinity of site
2016	Aerial Photography from Google Maps	Town largely as shown on modern maps.	• Midmill Business Park has expanded.
2023	Aerial Photography from Google Maps	No significant changes noted.	No significant changes noted.

To summarise, the town of Kintore developed throughout the 20th century. A number of sand and/or gravel quarries have existed in the study area and the vicinity. Other industrial land uses include smithies, garages, a saw mill, an electrical substation, and depots. Sensitive land uses include schools and archaeological features such as the historic remnants of the Aberdeen Canal.

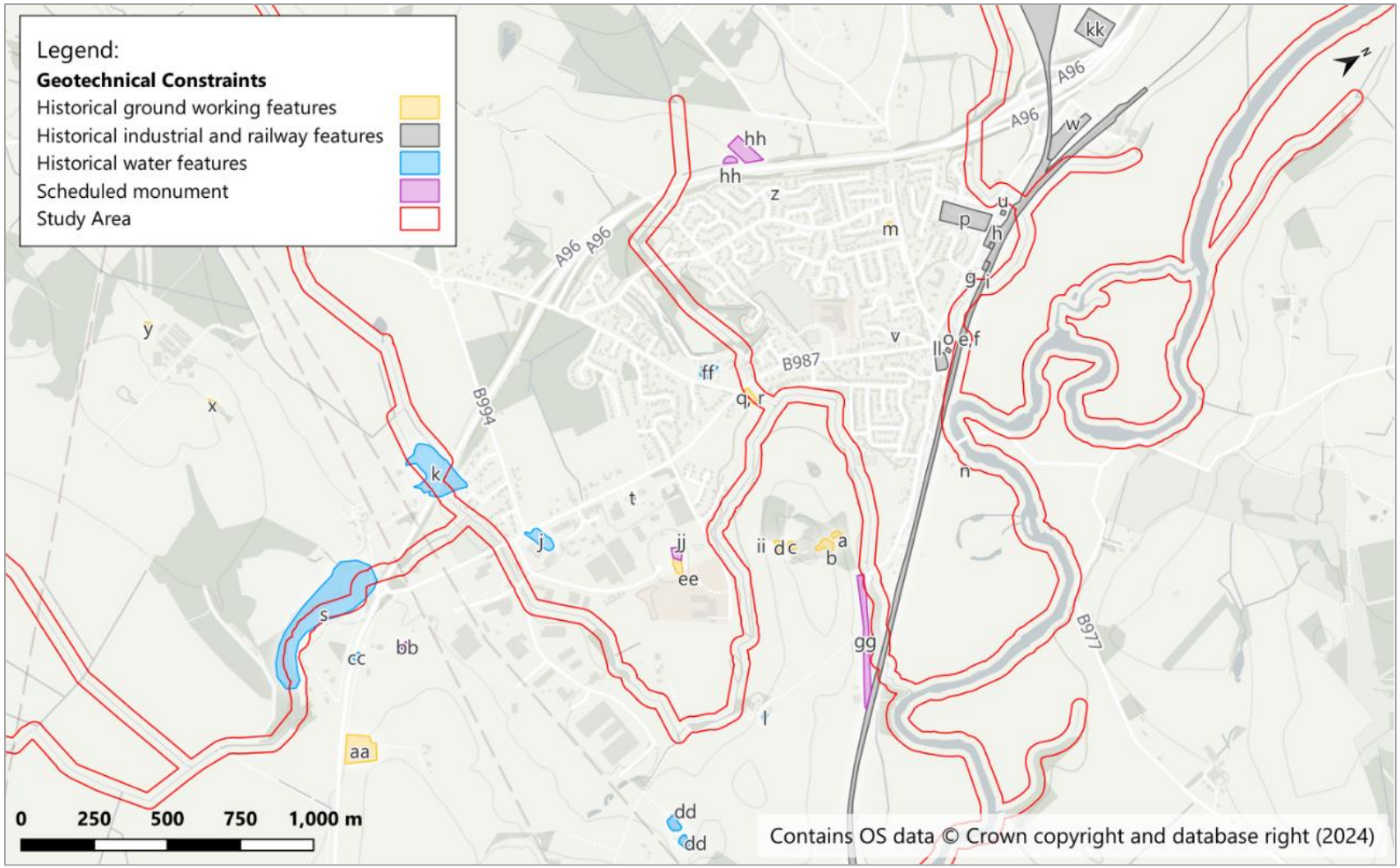

Figure 2: Potential sources of contamination

3.3 Utilities and buried services

At the time of writing, detailed service plans were not available for the study area. Consequently, the exact locations and types of existing underground services could not be confirmed. It is recommended that utility surveys be conducted prior to any intrusive works to avoid potential risks associated with unknown services.

3.4 Published geology

Geology maps and memoirs

The geology underlying the study area is shown on the British Geological Survey (BGS), England and Wales, New Series 1:63,360/1:50,000 geological map series, 76, Inverurie, Solid and Drift and on the British Geological Survey online interactive mapping service GeoIndex Onshore .

Superficial deposits are shown to comprise Alluvium (clay, silt, sand, and gravel) along the watercourses within the study area, and Glaciofluvial Sheet Deposits (gravel, sand, and silt). Some areas away from the watercourses may be underlain by the Banchory Till Formation (sandy, gravelly or bouldery diamictons containing clasts of the local bedrock), particularly in the south of the study area. Pockets of Peat are mapped at discrete locations near the River Don (near the "Rumbling Pot" oxbow lake) in the east of the study area and near the Torry Burn in the west. River Terrace Deposits (comprising mainly sand and gravel) are mapped in the centre of the study area, along Bridgealehouse Burn.

Bedrock geology is indicated to comprise the Kemnay Pluton (a granite), with the possibility of the Aberdeen Formation (a metamorphic rock) to the south of Broomhill Plantation.

Areas of worked ground are shown on the geological map, roughly at the locations of former quarries.

BGS boreholes

The BGS GeoIndex Interactive Map shows 192 records of historical ground investigations that are applicable to the study area, two of which are confidential. The majority of these are associated with the A96 Kintore bypass. The six publicly available records associated with other developments and a selected 15 no. records associated with the bypass were reviewed to gain information about the geology beneath the study area. A summary of the available exploratory hole records is presented in Table 3-2.

Table 3-2: Summary of historical ground investigation exploratory holes

Exploratory hole ref	Year	Final depth (m bgl)	Ground level (mOD)	Grid reference (ESPG:27700)		Comments
				Easting	Northing	
NJ71NE15078/TP15	1987	3.0	unknown	378857	816740	Kintore Bypass
NJ71NE15077/TP39	1990	3.5	62.455	378605	816668	Kintore Bypass
NJ71NE15077/34	1990	11.5	48.517	378746	816805	Kintore Bypass
NJ71NE15077/35	1990	19.5	48.544	378705	816818	Kintore Bypass
NJ71NE15077/31	1990	14.7	62.382	378661	816506	Kintore Bypass
NJ71NE15077/51	1990	9.6	51.481	378362	815639	Kintore Bypass

Exploratory hole ref	Year	Final depth (m bgl)	Ground level (mOD)	Grid reference (ESPG:27700) Easting	Northing	Comments
NJ71NE15077/TP67	1990	1.5	50.231	378387	815559	Kintore Bypass
NJ71SE15077/16	1990	14.4	62.513	378682	814874	Kintore Bypass
NJ71SE15078/TP7	1987	2.0	unknown	378764	814820	Kintore Bypass
NJ71SE15077/TP28	1990	2.0	6.0957	378772	814629	Kintore Bypass
NJ71SE15077/TP24	1990	2.0	61.465	378840	814535	Kintore Bypass
NJ71SE15077/TP18	1990	3.7	65.692	379033	814174	Kintore Bypass
NJ71SE15077/4	1990	7.5	64.506	379041	814367	Kintore Bypass
NJ71SE15077/TP16	1990	3.6	69.289	379099	814118	Kintore Bypass
NJ71SE15077/TP9	1990	4.3	74.648	379283	813911	Kintore Bypass
NJ71SE1	1984	8.0	69	377760	814490	
NJ71SE2	1984	8.0	63	378560	814910	
NJ81NW3	1984	20.0	47	380040	815990	
NJ71SE5	1984	5.0	57	379760	814930	
NJ71NE5	1984	10.0	57	378560	815910	
NJ71NE6	1984	7.0	46	379200	817100	

Geological summary

Based on reviewed information, the anticipated geological succession and spatial distribution encountered at the study area has been summarised in Table 3-3.

Table 3-3: Summary of encountered geology from borehole records.

Stratum	Thickness (m)	Description & Commentary
Made Ground	1.6	Anticipated to consist of reworked natural material with anthropogenic inclusions. Only encountered in one of the reviewed logs but anticipated to be present at any location associated with previous development. BGS mapping indicated the presence of worked ground at locations in the northern portion of the study area, consistent with areas of suspected quarrying.
Topsoil	0.2 to 0.7	Present at most exploratory locations
Sand and gravel	0.7 to 16.1	The majority of superficial deposits encountered in the study area are granular, which is in keeping with the published geological mapping.
Till	0.6 to 5.4+	Material interpreted as till includes the typical sandy gravelly clay (with some cobbles and boulders at some locations), and also firm to stiff silt and very dense sand and gravel or medium dense occasionally very gravelly sand.
Granite	Not proven	Caledonian granite. Noted as weathered for the first 0.5m to 2.6m where encountered. Encountered 5.4 to 9.6 m bgl.

3.5 Geotechnical hazards

Landslides, running sand conditions, shrink swell clays, collapsible deposits, compressible deposits, and ground dissolution are conditions which may present a geotechnical hazard. The

GeoSureHex data and professional judgement were used to assess the risks associated with these conditions for the study area (BGS, 2020).

The National Landslides Database is the definitive source of landslide information for Great Britain. No records from this data base appear in the study area (BGS, 2024). GeoSureHex mapping indicates a low level of susceptibility to landslides.

GeoSureHex mapping indicates a low level of susceptibility to running sand. Running sand conditions were not noted in the borehole logs reviewed, although some trial pits were terminated due to collapsing pit sides.

GeoSureHex mapping indicates a low or moderate level of susceptibility to shrink swell. Although clay was encountered in approximately half the exploratory locations, it was primarily a glacial till, which is not noted for susceptibility to shrink swell. While this risk cannot be ruled out, it is considered low.

Collapsible deposits are those with a mixture of silt/clay and larger particles, where if the finer particles wash away, voids have the potential to form. GeoSureHex mapping indicates a low level of susceptibility to collapsible ground.

Compressible deposits are those typically comprising peat (or significant organic content) or from landfill (primarily associated with putrescible waste). Large quantities of peat have not been encountered in the study area investigation records noted, although pockets are noted on the geological mapping. While some areas of landfilling or suspected quarry backfilling do exist in and near the study area, it is not known what the contents were. Therefore, this risk cannot be ruled out. GeoSureHex mapping indicates a low level of susceptibility to compressible deposits for this area; the risk associated with compressible ground may be locally high due to the former quarries and peat noted on mapping.

Ground dissolution is associated with chalk, limestone, gypsum, and salt. As none of these are present in the study area and the GeoSureHex mapping indicates a low level of susceptibility to ground dissolution, the risk is considered very low.

3.6 Hydrology

The study area is centred on the River Don and it's four tributaries in the town of Kintore. These tributaries are the Loch Burn running north-south; Bridgealehouse Burn and Torry Burn, both running east-west; and the Tuach Burn, which curves around Tuach Hill and Gauch Hill.

The study area is within the River Don surface water body catchment (water body ID 23269). This is currently classed as a heavily modified water body due to agricultural land drainage.

A review of the available flood maps shows a high likelihood (annual 10% chance) of flooding from the River Don in the eastern portion of the study area, and from the Bridgealehouse, Loch, Tuach, and Torry Burns where they flow through the study area. Surface water flooding (up to 10% annual chance) is also indicated at a number of discrete locations across the town, of particular note at the western extent of the Torry Burn within Kintore, between Hallforest Avenue and the A96 (SEPA, 2024).

The study area is not located within a surface water Drinking Water Protected Area.

3.7 Hydrogeology

The hydrogeological conditions beneath the study area have been inferred from data available on the Scotland's Environment mapping and the BGS Hydrogeological map of Scotland 1:625,000 (BGS, 1988).

A summary of the hydrogeological setting of the study area, with respect to the anticipated geological sequence is presented below in Table 3-4.

Table 3-4: Hydrogeological summary

Condition	Description
Aquifer characteristics	The study area is underlain by low productivity aquifers, an unnamed igneous intrusion under the majority of the study area and the Argyll group in the southern extremity. Flow in both is characterised as through fractures and discontinuities. Superficial deposits are not characterised on the Hydrogeological Map of Scotland .
Groundwater vulnerability	Groundwater quality is classified by SEPA as 'Good' in the Scotland's Environment mapping.
Groundwater Flooding	No information regarding groundwater flooding was available.
Depth to groundwater and flow	The depth to the groundwater table in previous investigations was between 0.3m bgl and 6.3m bgl. It is anticipated to vary depending on local topography and geology, with a typical depth to groundwater of between 1.5 and 2.5m. Shallow groundwater in the study area is anticipated to flow in an easterly direction, i.e. towards and in the direction of flow of the River Don, though it will be affected by the topography of the study area.
Licensed groundwater abstractions	No information has been obtained regarding groundwater abstractions.
Source protection zones	Mapping from SEPA indicates that the study area is in a Drinking Water Protected Area (Groundwater).

3.8 Unexploded Ordnance

A review of publicly available unexploded ordnance (UXO) risk maps indicates that the study area is located in an area with low potential for wartime bombs to be present . Additionally, anecdotal information on the town's website indicates that a failed attempt to demolish the Aberdeenshire Electric Company Reservoir with explosives was made in the 1930s . It is not known whether any unexploded ordnance from this attempt remain.

3.9 Radon and ground gas potential

The potential sources of methane and associated gases requiring consideration are generally from organic soils or bedrock, landfills, significant degradable/putrescible materials in made ground, mine workings, wetlands, cemeteries/burial grounds, sewers and gas mains.

With regards to the potential for methane migration into the study area from soils or bedrock; the study areas geology, outlined in Table 3-3, is not considered likely to be organic rich. Localised areas of peat have been mapped in the vicinity. Should organic rich soils be found in a ground investigation, the potential for ground gas should be assessed.

Landfilling and infilled ponds both exist in or near the study area and these do pose a potential for ground gas generation.

With regards to the risk of radon generation and migration to the study area, the UK radon risk map has been reviewed. The map indicates that the majority of the study area has a maximum radon potential of 3-5%. This rises to 10-30% in the south-eastern portion of the study area.

Further information should be sought regarding protection measures, should buildings be constructed in association with this flood protection scheme, particularly in areas to the south-east.

3.10 Mining and quarrying

Evidence has been sought to identify any mining, quarrying, and land reclamation operations, past and present, which have taken place within the vicinity of the study area.

Coal Mining

Information from the Coal Authority (Coal Authority, 2024) indicates the study area is not located within a Coal Mining Reporting Area. As such, a mining report is not required for this study area.

Quarrying and Shallow Workings

Sand and or gravel extraction took place at a number of locations in the vicinity of the study area. Given the distance of these works from the defined study area, it is not considered likely that they would cause unidentified void hazards.

3.11 Cultural heritage

Records on the Scotland's Environment map regarding cultural heritage were reviewed . No Geological Conservation Review Sites, country or national parks, battlefield inventory sites, gardens and designed landscapes, or world heritage sites were noted within 250m of the study area.

Four scheduled monuments were noted in the vicinity of the study area as indicated in Table 3-5, and in Figure 2.

Table 3-5: Scheduled monuments

Coordinates (Easting, Northing)	**Figure ID**	**Designation Reference**	**Designation Title**
380051, 815576	gg	SM7674	*"Aberdeenshire Canal, remains of, NW of Brae of Kintore"*
378393, 816050	hh	SM12465	*"Deer's Den, roundhouses 195m and 250m S of"*

379503, 815158	jj	SM3958	*"Midmill, long cairn, 400m SSE of Tuach Hill"*
379568, 815458	ii	SM50	*"Tuach Hill, stone circle and enclosure 130m SW of Gallow Top"*

Given the above and the number of tumuli (barrow burials) in the vicinity of the study area as observed in the historic maps (Section 3.2), it is considered prudent to seek additional archaeological advice prior to construction activities.

3.12 Environmentally sensitive sites

The study area is not located within 1km of an environmentally sensitive designation (SSSI, SPA, SPC, RAMSAR).

3.13 Environmental Database Information

Relevant environmental permits and incidents made publicly available are summarised below in Table 3-6.

Table 3-6: Summary of environmental database information

Data type	Entries on-site	Entries off-site	Details
Agency and hydrological			
Pollution Prevention and Control (PPC) permits.	0	1	At Midmill Industrial estate
Waste and Landfill			
Active or recent landfills.	0	0	
Historic / closed landfills.	0	0	
Waste Management Licence			
Hazardous substances/ industrial land uses			
Contaminated land Part 2A register entries and notices.	0	0	
Scottish Pollution Release Inventory	0	0	
Aberdeenshire public register of contaminated land	0	0	
**Entries have only been included within the table where they are located within a 250m radius of the study area or, where they fall outside of this radius but are considered to comprise a significant entry.*			

4. PRELIMINARY GEOENVIRONMENTAL ASSESSMENT

4.1 Preliminary Conceptual Site Model (pCSM)

In order to summarise the key risks associated with the study area, a preliminary conceptual site model (pCSM) has been produced to summarise the key geoenvironmental risks anticipated at the study area. This represents the understanding of the potential pollutant linkages assumed to exist in the study area before undertaking any intrusive investigations.

Methodology

A pollutant linkage and therefore a risk of harm exist when a contaminant, receptor and pathway to this receptor are present. The terminology used is as follows:

- A contaminant – a substance that is in, on or under the land and has the potential to cause pollution of controlled waters.
- A receptor – in general terms, something that could be adversely affected by a contaminant, such as people, and ecological system, property, or a water body.
- A pathway – a route or means by which a receptor can be exposed to or affected by a contaminant.
- Risk - a combination of the probability, or frequency, of occurrence of a defined hazard and the magnitude of the consequences of the occurrence.

The pCSM is summarised in Table 4-1 along with comments and qualitative risk ratings based on professional judgment. The resultant potential pollutant linkages have been assigned qualitative risk ratings in line with Table 8-1 and Table 8-3, in Appendix A.

Table 4-1: Preliminary Conceptual Site Model (pCSM)

Source and Contaminants	Potential pathway	Receptor	Probability	Severity	Risk	Mitigation/ Comment
<u>Onsite Industrial Land uses:</u> • Ponds and reservoirs. • Electrical land use (substation and power house). • Railway land (including railway and sidings, station, and goods station). Depending on location of works, potential contaminants include: ground gases (carbon dioxide, methane, hydrogen sulphide), metals, hydrocarbons (including petroleum hydrocarbons, VOCs, SVOCs, PAHs, BTEX, phenols), sulphate, asbestos, PCBs, and/or ammonia.	Inhalation of soil-derived dust, gases, vapours and asbestos fibres. Dermal contact with soil and soil-derived dust. Ingestion of soil.	Human Health-construction and maintenance workers	L	3	A	Ground investigation to determine if sources are present and pollutant linkage exists. Remediation may be required if significant sources of contamination identified. Residual risks are to be managed through appropriate PPE, good personal hygiene and good working practices.
	Ingestion of plants grown in contaminated soil. Inhalation of soil-derived dust, gases, vapours and asbestos fibres. Ingestion of soil. Dermal contact with soil and soil-derived dust.	Human Health-residents, school users.	L	4	AR	
	Leaching and dissolution with vertical/lateral migration, and migration along preferential pathways into groundwater.	Controlled Waters-Shallow Groundwater	M	3	AR	
	Vertical/lateral migration within groundwater and surface water run-off.	Controlled Waters-Surface water	M	3	AR	
	Direct contact with sulphate and other aggressive chemicals, or chemicals may flow with groundwater into contact with concrete buildings.	Buildings and structures	L	2	A	
	Direct contact with sulphate and other aggressive chemicals, or chemicals may flow with groundwater, into contact with remains damaging them.	Archaeological remains	L	2	A	

Source and Contaminants	Potential pathway	Receptor	Probability	Severity	Risk	Mitigation/ Comment
<u>Off-site Industrial Land uses:</u> • Sand and/or gravel quarries (backfill unknown, some now ponds). • Depot with tanks. • Garages (petrol filling stations). • Sewage tank. • Smithy. • Sawmill. • Cemetery. Depending on location of works, potential contaminants include: Metals, hydrocarbons (including petroleum hydrocarbons, VOCs, SVOCs, PAHs, BTEX, phenols), PCBs, dioxins, sulphate, asbestos, ammonia, pathogens, and/or ground gases (carbon dioxide, methane, hydrogen sulphide).	Inhalation of dust, gases, vapours and asbestos fibres. Dermal contact with soil-derived dust or contaminated groundwater. Ingestion of soil.	Human Health-construction and maintenance workers	L	3	A	Ground investigation to determine if sources are present and pollutant linkage exists. Remediation may be required if significant sources of contamination identified. Residual risks are to be managed through appropriate PPE, good personal hygiene and good working practices.
	Inhalation of soil-derived dust, gases, vapours and asbestos fibres. Dermal contact with soil-derived dust. Ingestion of soil.	Human Health-residents, school users.	L	3	A	
	Lateral migration within groundwater onto site.	Controlled Waters-Shallow Groundwater	L	3	A	
	Aggressive chemicals may flow with groundwater into contact with concrete.	Buildings and structures	L	2	A	

5. PRELIMINARY GROUND RISK REGISTER

The ground risks have been considered for the proposed works, using the information presented in this report and our current understanding and knowledge of the scheme. A risk matrix identifies the potential risks to the scheme during the feasibility, design and construction stages. For each potential hazard or risk identified, a risk rating is assigned prior to identification of risk consequence and mitigation measures. The full risk assessment methodology is presented in Appendix A. Currently anticipated risks and mitigation measures for the scheme are given in Table 5-1.

Table 5-1: Ground Risk Register

Risk ID	Hazard	Consequence	Likelihood	Severity	Risk	Mitigation Measures
1	Made Ground	Variable ground, differential settlement, and the potential to encounter buried structures.	M	3	AR	Further GI to determine depth and extent of Made Ground underlying the proposed works.
		Potential land contamination.	H	3	AR	
2	Unanticipated ground conditions	Failed structures (e.g. retaining wall).	M	3	AR	Further GI underlying the proposed works to confirm ground conditions.
3	High groundwater levels	Excavation instability.	H	3	AR	Further GI underlying the proposed works to confirm ground conditions. Dewatering measures may be required during excavations.
4	Potentially contaminated ground	Risk to Human Health and Controlled Waters. Soils unsuitable for reuse on site. High cost to dispose excavated soils offsite. Delays in program.	H	3	AR	Carry out ground investigation to carry out a Generic Quantitative Risk Assessment and waste classification of proposed excavated soils.
5	Potential for shrink swell clay	Softened material difficult to work on. Cycling of shrinking and swelling may cause differential settlement issues and potential damage to structures.	L	3	A	Ground investigation to properly characterise shrinkability. Control surface water during excavation, proper excavation management (e.g. appropriately battered sides). Excavate foundations to suitable non-shrinkable stratum or replace with suitable non-shrinkable material.
6	Potential for Compressible deposits	Settlement causing structure damage or localised instability during construction.	L	3	A	Found on suitable non-compressible strata, either through the use of piles or excavation to replace with suitable material.

Risk ID	Hazard	Consequence	Likelihood	Severity	Risk	Mitigation Measures
7	Potential for Ground Gas	Risk to Human Health. Potential for explosion.	M	4	AR	Carry out ground investigation. If significant deposits of peat or other organic soils are encountered, a risk assessment (and potentially additional monitoring) should be undertaken to characterise the risk. If works are proposed in area of former quarry and are anticipated to include confined spaces, ground investigation should include appropriate gas monitoring and risk assessment.

6. CONCLUSIONS AND RECOMMENDATIONS

The risks identified in the Ground Risk Register (Table 5-1) should be transferred to the project risk register.

It is considered likely that further information on the ground conditions will be needed to determine the geotechnical design of the proposed flood protection scheme. Likewise, the land contamination risks identified should be further quantified where development is proposed. Ground investigation would also inform a soil reuse and disposal options assessment.

The finalised scope of an intrusive ground investigation should be determined following confirmation of the detailed designs. However, at this stage, it is considered likely that further information would be required to:

- establish the ground conditions underlying the area of the proposed works including the extent and thickness of any Made Ground;
- investigate specific potential sources of contamination identified in the pCSM;
- determine groundwater depth and flow conditions;
- assess geotechnical properties of soils;
- address data gaps; and
- further quantify, address and mitigate ground related risks identified.

The ground investigation should be carried out in general accordance with the recommendations of BS5930:2015+A1:2020, which maintains compliance with BS EN 1997-1 and 1997-2 and their related standards. Potentially contaminated sites should be investigated in accordance with BS 10175:2011+A2:2017 'Investigation of potentially contaminated sites'. Prior to conducting intrusive works, utility service plans should be obtained and buried service clearance undertaken in line with PAS128 guidance.

Investigation should include an assessment of ground gas including radon if structures with enclosed spaces are proposed.

Given the number of archaeological features in the vicinity of the study area, specialist advice should be sought prior to construction. Furthermore, an archaeological watching brief may be required for any intrusive ground investigations.

It is a requirement that the full ground investigation (GI) works as described above are carried out prior to the detailed design of any scheme being taken forward.

7. REFERENCES

Aberdeenshire Council, 2011. *Public Regsiter of Contaminated Land.* [Online]
Available at: https://www.aberdeenshire.gov.uk/media/17044/public-register-of-contaminated-land-index-nov11.pdf
[Accessed September 2024].

AGS, 2021. *Assessment and Control of Asbestos Risk in Soil- Part 1: Protection of personnel working on Ground Investigations,* s.l.: s.n.

AGS, 2021. *Assessment and Control of Asbestos Risk in Soil- Part 2: Protection of Personnel working in Geotechnical and Geoenvironmental Laboratories,* s.l.: s.n.

BGS, 1988. *Hydrogeological Map of Scotland.* [Online]
Available at: https://largeimages.bgs.ac.uk/iip/mapsportal.html?id=1003988
[Accessed 2024].

BGS, 1988. *Hydrogeological map of Scotland (1:625,000).* [Online]
Available at: https://webapps.bgs.ac.uk/data/maps/home.html
[Accessed September 2024].

BGS, 2002. *Geological Survey of England and Wales, 1:50,000, Sheet 76, Inverurie, Solid and Drift edition.* [Online]
Available at: https://webapps.bgs.ac.uk/data/MapsPortal/map.html?id=11118300011118
[Accessed September 2024].

BGS, 2015. *BGS Earthwise East Grampian Drift Group.* [Online]
Available at:
https://earthwise.bgs.ac.uk/index.php/East_Grampian_Drift_Group,_Quaternary_lithostratigraphy,_Cainozoic_of_north-east_Scotland
[Accessed October 2024].

BGS, 2024. *BGS maps portal.* [Online]
Available at: https://www.bgs.ac.uk/information-hub/bgs-maps-portal/
[Accessed 2024].

BGS, 2024. *GeoIndex Onshore.* [Online]
Available at: https://bit.ly/3cnZmMd
[Accessed September 2024].

BGS, 2024. *The BGS Lexicon of Named Rock Units.* [Online]
Available at: https://webapps.bgs.ac.uk/lexicon/
[Accessed September 2024].

BRE, 2005. *Special Digest 1 Concrete in aggressive ground. 3rd edition (Includes February 2017 amendments).* [Online]
Available at: https://bregroup.com/

BSI, 1990. *BS 1377:1990 'Methods for Test for Soils for Civil Engineering Purposes' Parts 1 to 9,* s.l.: s.n.

BSI, 2005. *BS EN ISO 22476-3:2005 Geotechnical investigation and testing. Field testing. Standard penetration test (+A1:2011) (incorporating corrigendum February 2007),* s.l.: s.n.

BSI, 2007. *BS EN 1997-2:2007 Eurocode 7: Geotechnical design. Ground investigation and testing (incorporating corrigendum June 2010),* s.l.: s.n.

BSI, 2013. *BS8576:2013. Guidance on investigations for ground gas – permanent gases and volatile organic compounds (VOCs).,* s.l.: s.n.

BSI, 2014. *BS EN 1997-1:2004 Eurocode 7: Geotechnical design. General rules (+A1:2013) (incorporating corrigendum February 2009),* s.l.: s.n.

BSI, 2015. *BS 5930:2015 Code of practice for ground investigations (+A1:2020),* s.l.: s.n.

BSI, 2017. *BS 10175:2011+A2:2017 Investigation of potentially contaminated sites - code of practice,* s.l.: s.n.

BSI, 2019. *BS 8485:2015+A1:2019. Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings.,* s.l.: s.n.

BSI, 2020. *BSI 21365: 2020 Soil quality - Conceptual site models for potentially contaminated sites,* s.l.: s.n.

Carter, M. & Bentley, P. S., 2016. *Soil Properties and their Correlations.* s.l.:Wiley.

CIRIA, 2001. *Contaminated land risk assessment: A guide to good practice,* Basingstoke: CIRIA.

CIRIA, 2007. *C665 Assessing risks posed by hazardous ground gases to buildings,* s.l.: Retrieved from Construction Industry Research and Information Association: https://www.ciria.org.

CIRIA, 2009. *CIRIA Report C682. The VOCs Handbook. Investigating, assessing and managing risks from inhalation of VOCs at land affected by contamination.,* s.l.: s.n.

CIRIA, 2014. *Special Publication SP 168 Asbestos in soil and made ground: a guide to understanding and managing risks.* [Online]
Available at: https://www.ciria.org/

CL:AIRE, 2010. *Soil Generic Assessment Criteria for Human Health Risk Assessment.* [Online]
Available at: https://bit.ly/3QZDG84

CL:AIRE, 2011. *Definition of Waste: Code of Practice: Development Industry Code of Practice,* s.l.: s.n.

CL:AIRE, 2014. *Development of Category 4 Screening Levels (C4SLs) for Assessment of Land Affected by Contamination,* s.l.: s.n.

CL:AIRE, 2016. *CAR-SOIL: Control of Asbestos Regulations 2021, Interpretation for Managing and Working with Asbestos in Soil and Construction and Demolition Materials: Industry guidance,* s.l.: s.n.

Coal Authority, 2024. *The Coal Authority Interactive Viewer.* [Online]
Available at: https://www.groundstability.com/public/web/home.xhtml

Das, B. M., 2013. *Fundamentals of geotechnical engineering.* s.l.:Cengage Learning.

DEFRA & EA, 2004. *Model Procedures for the Model Procedures for the (Contaminated Land Report 11),* s.l.: s.n.

DEFRA, 2012. *Contaminated Land Statutory Guidance: Environmental Protection Act 1990:Part 2A,* s.l.: s.n.

EA, 2008. *Compilation of data for priority organic pollutants for derivation of Soil Guideline Values (SC050021/SR7),* s.l.: s.n.

Environment Agency, 2009. *A Guide to using Soil Guideline Values,* s.l.: s.n.

Environment Agency, 2015. *Contaminated land exposure assessment (CLEA) tool,* s.l.: s.n.

Environment Agency, 2021. *Land contamination risk management (LCRM).* [Online]
Available at: https://www.gov.uk/government/publications/land-contamination-risk-management-lcrm
[Accessed 2023].

Environment Agency, 2021. *Waste classification technical guidance WM3 v1.2.GB,* s.l.: s.n.

Google Earth, 2024. *Google Earth.* [Online]
Available at: https://earth.google.co.uk
[Accessed 2024].

Google, 2024. *Google Maps Street View.* [Online]
Available at: https://www.google.com/streetview/
[Accessed 2024].

Highways England, 2020. *CD 622 Managing Geotechnical Risk,* s.l.: Highways England.

Historic England, 2024. *Aerial Archaeology Mapping Explorer.* [Online]
Available at: https://historicengland.org.uk/research/results/aerial-archaeology-mapping-explorer/
[Accessed 2024].

Look, B., 2007. *Handbook of geotechnical investigation and design tables.* s.l.:Taylor & Francis.

LQM/CIEH, 2015. *The LQM/CIEH S4ULs for Human Health Risk Assessment.* Nottingham: Land Quality Press.

National Library of Scotland, 2024. *National Library of Scotland index online viewers.* [Online]
Available at: https://maps.nls.uk/

NPPF, 2021. *National Planning Policy Framework.* [Online]
Available at: https://www.gov.uk/government/publications/national-planning-policy-framework--2

Ordnance Survey, 2024. *OS Maps Online.* [Online]
Available at: https://osmaps.com/
[Accessed 2024].

Scottish Government, 2024. *Scotland's Environment Map.* [Online]
Available at: https://map.environment.gov.scot/sewebmap/
[Accessed September 2024].

SEPA, 2014. *Drinking water protected areas - Scotland river basin district: maps.* [Online]
Available at: https://www.gov.scot/publications/drinking-water-protected-areas-scotland-river-basin-district-maps/
[Accessed 19 09 2024].

SEPA, 2022. *Scottish waste sites and capacity tool.* [Online]
Available at: https://www.sepa.org.uk/environment/waste/waste-data/waste-data-reporting/waste-site-information/
[Accessed September 2024].

SEPA, 2022. *Water Classification Hub.* [Online]
Available at: https://bit.ly/3wzauMU

SEPA, 2024. *Scottish Flood Hazard and Risk Information.* [Online]
Available at: https://map.sepa.org.uk/floodmaps
[Accessed 19 09 2024].

SEPA, 2024. *Special Sites.* [Online]
Available at: https://www.sepa.org.uk/regulations/land/contaminated-land/special-sites-in-scotland/
[Accessed September 2024].

SEPA, 2024. *The Scottish Pollutant Release Inventory.* [Online]
Available at: https://informatics.sepa.org.uk/SPRI/
[Accessed September 2024].

The Royal Burgh of Kintore, 2024. *The History of Kintore.* [Online]
Available at: https://kintore.org.uk/the-history-of-kintore
[Accessed 30 09 2024].

UK Health Security Agency, 2024. *UK Radon Indicative Map.* [Online]
Available at: https://bit.ly/2zFVte3
[Accessed 2024].

Zetica, 2024. *UXO Risk Assessment.* [Online]
Available at: https://bit.ly/2DMxh9W
[Accessed 2024].

APPENDICES

APPENDIX A RISK ASSESSMENT METHODOLOGY

The criteria used for risk assessment are based on CD622 and C552 guidance documents. The severity and probability is classified according to the criteria in Table A-1 and Table A-2. The overall evaluation of the level of risk is shown in Table A-3 and recommended associated actions shown in Table A-4.

Table A-1: Likelihood/probability of the risk occurring

Code	Meaning	Geotechnical Risks (CD622)	Geoenvironmental Risks (CIRIA C552)
VL	Improbable/Negligible	So unlikely that it can be assumed that it will not occur, or it cannot occur	Contaminant linkage may be present but the circumstances under which harm would occur are improbable
L	Remote/Low likelihood	Unlikely but possible	Contaminant linkage may be present, and there is a possibility of the risk occurring although there is no certainty that it will do so.
M	Occasional/Medium likelihood	Likely to occur at some time	Contaminant linkage may be present, and it is probable that the risk will occur over the long term
H	Probable/Reasonably foreseeable	Likely to occur several times	
VH	Frequent/High likelihood	Likely to occur many times	Contaminant linkage may be preset, and risk is almost certain to occur in the long term, or there is evidence of harm to the receptor.

Table A-2: Severity/consequence of risk

Code	Meaning	Geotechnical Risks (CD622)	Geoenvironmental Risks (CIRIA C552)
1	Negligible	Resulting in no injury and no loss of working time	Damage to non-sensitive ecosystems or species Minor damage to buildings or structures No harm or pollution of water
2	Marginal	Resulting in a minor 'first aid' injury or a minor loss of working time	No significant harm to human health in either short or long term No pollution of sensitive controlled waters, no more than slight pollution of non-sensitive waters Significant damage to buildings or structures Requirements for protective equipment during site works to mitigate health effects
3	Serious	Resulting in an injury or illness which causes a period of absence from work	Harm to human health from long-term exposure Slight pollution of sensitive controlled waters (surface waters or aquifers) or pollution of other water bodies Significant effects on sensitive ecosystems or species
4	Critical	Resulting in a severe injury with much lost time	
5	Catastrophic	Resulting in a fatality or major disruption	Acute risks to human health Catastrophic damage to buildings/property (e.g. by explosion) Direct pollution of sensitive water receptors or serious pollution of other controlled water (watercourses or groundwater) bodies.

Table A-3: Assessed Risk

SEVERITY / LIKELIHOOD		Negligible 1	Marginal 2	Serious 3	Critical 4	Catastrophic 5
Improbable/Negligible	VL	N	N	A	A	A
Remote/Low likelihood	L	N	A	A	AR	AR
Occasional/Medium likelihood	M	A	A	AR	AR	UA
Probable/Reasonably foreseeable	H	A	AR	AR	UA	UA
Frequent/High likelihood	VH	A	AR	UA	UA	UA

Table A-4: Risk Response

Code	Meaning	Response needed
UA	Unacceptable	Action essential. Remediation, mitigation or site investigation required.
AR	Action required	Action required if reasonably practicable. Site investigation required.
A	Acceptable	Risk to be managed.
N	Negligible	No action required.